PATENT SPECIFICATION

700,833

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COMPLETE SPECIFICATION

Improvements in or relating to the automatic cleaning of cooling-water and like tubes

I, JOSEPH TAPROGGE, a German Citizen, of Eisenhammerweg 17, Essen-Kupferdreh, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement :—

The supervision of surface condensers and steam power plants has for its principal object to keep a running check upon the heat transmission in the condenser cooling tubes and to keep said transition at as high as possible an average value. The mechanical impurities, organic substances, and hardness-forming substances contained in the cooling water, lead to deposits in the cooling tubes of the condenser and thereby to a deterioration of the heat transition from the steam through the walls of the condenser tubes to the cooling water; this deterioration of the heat transmission effects, at the same time, a reduction of the condenser efficiency and thereby of the total efficiency of the thermal power plant.

A great number of methods have been employed for removing noxious substances contained in the cooling water and for cleaning the cooling tubes.

In the case of non-circulation water cooling, chemical softening is generally too costly in view of the great quantities of water involved, and for the destruction of organic substances chlorine is at present frequently added to the cooling water. In circulation cooling systems, this chlorination method is likewise employed and the increased hardness of the re-circulated cooled water due to evaporation is counteracted by chemical softening.

Even in the case of entirely satisfactory preliminary treatment of the cooling water, it is however, in most cases, impossible to prevent impurities of the cooling water, generally of a mechanical nature, from becoming attached to the inside of the condenser and leading, in the course of time, to a considerable reduction of the condenser efficiency; as a consequence, it is necessary for the condenser tubes to be cleaned from time to time.

Loose sludge may be removed by increasing the velocity of the cooling water, by condenser rinsers and the like, solid sludge is removed by ordinary wire brushes, while very hard sludge deposits are drilled out, and solid stone (lime) deposits dissolved chemically. In all the possibilities referred to it is not always easy to remove the deposits entirely without damaging the tubes, mainly because with all these methods cleaning is only effected when a certain degree of soiling of the condenser has taken place, i.e., after more or less extended periods of time ascertained by means of an economy calculation. The cleaning of the condenser can only be effected when the condenser is out of operation or, if a divided water chamber of twin condensers are provided only while working at a reduced load and with a correspondingly impaired vacuum.

Due to the fact that each following cleaning of the condenser can only be effected after the lapse of a certain period of time, the level of the average heat transmission of the cooling tubes, or of the condenser efficiency is, in many cases, considerably lower than the maximum values obtained immediately after cleaning. An added factor is that for reasons connected with the running of the plant it is sometimes necessary for the operating period of the condenser ascertained as being economical to be exceeded, the average vacuum of the condenser being further impaired as a necessary consequence of this. With the methods of cleaning hitherto customary, the average

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vacuum of a condenser cannot be appreciably further improved in view of the high costs of preliminary treatment (conditioning) of the cooling water and of cleaning the condenser.

The present invention has for its object to provide a method of auto-cleaning the tubes of heat exchangers such as surface condensers, coolers and the like which, due to its character and the simplicity of means, only involves low initial and operating costs which for example, in the case of a surface condenser, enables the average condenser vacuum to be considerably increased.

The invention is determined by the consideration that the more frequently the cooling tubes of a condenser are cleaned, the less will naturally be the degree of soiling in each case, and the less will be the expenditure of power required for mechanically cleaning the cooling tubes.

According to the invention, rubbing bodies are arranged to be conveyed by a heat exchange medium such as cooling water along the walls of the tubes, said bodies being separated from the spent medium leaving the heat exchanger by means of an intercepting and guiding device, such as a screen, a cataract or the like, and being returned to the inlet and introduced into the fresh medium entering the heat exchanger. Referring, for example, to a condenser, the heated cooling water leaving the condenser may be all conducted through a device serving for permitting the cooling water to flow on unimpeded into the cooling water outlet conduit, while the rubbing bodies may be intercepted and conducted with a branch stream of the heated cooling water into a return conduit through which, in a given case by means of a pump (return pump), they are re-introduced into the cooling water flowing into the condenser, thus once more commencing their circulation.

The invention also provides a method and apparatus for cleaning and reconditioning the rubbing bodies after use. According to this feature of the invention the rubbing bodies, after leaving the cooling tubes of the condenser or the like, are conducted in continual succession over a cataract which permits the flow of water to pass substantially without hindrance but which, like a sieve, holds the rubbing bodies back, subjecting the same to repeated dropping impacts producing elastic deformation, freeing them from retained foreign particles and return the thus regenerated rubbing bodies to the cooling water supplied to the cooling tubes, for example through a return pipe.

According to a modification of this method some of the rubbing bodies leaving the cataract may be withdrawn, preferably by means of a lock device, from the shunt circuit and then re-introduced after thorough regeneration or replaced by others. The method may be further modified by providing the rubbing bodies with a coating of abrasive material.

The invention is illustrated by way of example in the accompanying drawings in which Fig. 1 is a diagram showing a condenser plant incorporating one embodiment of the present invention:

Figs 2 and 3 show modifications thereof:

Figs. 4 and 5 are an axial section and plan view respectively of one form of cleaning device for the rubbing bodies;

Figs. 6 and 7 are details thereof shown at a larger scale:

Figs. 8 and 9 illustrate the manner in which the device may be cleaned;

Figs. 10 and 11 are sectional views illustrating two modifications;

Fig. 12 is an axial section of another modification;

Fig. 13 is a cross-section on line A—B of Fig. 12; and

Fig. 14 is a diagrammatic view showing an axial acceleration pump for use in conjunction with the method of the present invention.

Referring first to Figs. 1 to 3 the condenser elements, such as cooling tubes 19, are arranged to be cleaned by rubbing bodies 27 in turn at short intervals during operation of the condenser, the condenser liquid, such as cooling water serving, on its way through the condenser, for carrying the rubbing bodies along and also acting, within the cooling tubes, as pressure medium for these bodies. Advantageously, the rubbing bodies carry out, during the cleaning of the condenser, a continuous circulation by being conveyed through the condenser by the cooling water, intercepted at the condenser outlet 21 by a suitable device 23 and returned again into the cooling water supplied to the condenser by the condenser cooling water pump 16. The heated cooling water leaving the condenser may be all conducted through the device 23, the latter permitting the cooling water to flow on unimpeded into the cooling water outlet conduit 22, while causing the rubbing bodies to be intercepted and conducted with a branch stream of the heated cooling water into a return or shunt conduit 24 through which in a given case (Figs. 1 and 2) by means of a pump 25 (return pump), they are re-introduced into the cooling water flowing into the condenser at the condenser inlet side, thus once more commencing their circulation.

The intercepting and conducting device for the rubbing bodies may, for example,

consist of a funnel-shaped strainer 23, or of a screen or grating built into the condenser outlet pipe 22 at an angle, and connected to a return device for the rubbing bodies. This device may comprise a return pipe 24 equipped with a return pump 25, which may be constructed as a centrifugal pump, water injector pump, or the like.

It is generally possible to convey the rubbing bodies without damage through the condenser cooling water pump 16. In this case (Figs. 2 and 3), the return conduit 24 for the rubbing bodies may open into the suction connection 15 of the condenser cooling water pump 16. Since, on the other hand, in most practical cases (Fig. 3), a positive pressure drop exists during operation between the condenser outlet conduit 22 and the suction connection 15 of the cooling water pump 16, a separate return pump for the rubbing bodies becomes unnecessary. This, therefore, constitutes the normal and simplest form of apparatus for carrying out the method of the invention, in which in addition to the rubbing bodies there is only required in the main the intercepting and conducting device 23 at the condenser outlet 22 and the return conduit 24 to the suction connection 15 of the condenser cooling water pump 16. The elasticity and size of the rubbing bodies is so chosen that as great as possible a rubbing surface can be formed in the cooling tube. The rubbing bodies are subjected in the cooling tubes to a maximum drive corresponding to the pressure drop which in operation of the condenser develops between the inlet and outlet ends of the cooling tubes 19 or of the water passages 20 in the condenser. This pressure drop corresponds mainly to the resistance to flow which the cooling water suffers in its path through the cooling tubes. In order to avoid the risk of the tubes becoming blocked, this drop must be so great as to enable the cooling water to convey, if necessary, a plurality of rubbing bodies simultaneously through a cooling tube. This safety factor must be also taken into consideration in choosing the elasticity and size of the rubbing bodies. If the degree of contamination of the cooling water is low, it is not generally necessary to choose the cross-section of the rubbing bodies greater than that of the cooling tubes, the irregular movement of the rubbing bodies being sufficient for effecting the cleaning.

The rubbing bodies impinging upon the intercepting device 23 provided in the condenser outlet tube 22 are there cleaned by the cooling water moving past them and return into the circulation in a clean condition.

As material for the rubbing bodies sponge rubber is particularly suitable. The cleaning effect of this porous substance is so great that the deposit, which in view of the frequent cleaning of each individual pipe is only minute, is in each case entirely removed. While the rubbing bodies are forced through the cooling tubes by the cooling water, the water passing through them conveys the impurities detached from the walls of the tube in front of the rubbing bodies, this preventing the rubbing bodies from becoming excessively soiled.

As regards the shape of the rubbing bodies, the spherical shape is particularly advantageous. The fact that the surface of a sphere and accordingly its rubbing surface is great in relation to its volume permits a high degree of utilisation of the material. Furthermore, the resistance of a spherical rubbing body in the cooling tube is approximately equal in all positions, which is more particularly of importance at the entry into a cooling tube. Moreover, the interception and return of spherical rubbing bodies after passage through the condenser offers relatively little difficulty owing to the possibility of rolling movement.

Since the specific gravity of the rubbing bodies may be chosen equal or almost equal to that of water, they float in the cooling water. This capability of floating and the stirring by the condenser cooling water pump 16 or by special stirring apparatus 28 which may be fixed deflector sheets or rotary blades provided in the condenser supply passage 17 and in the water chambers 18 contributes to ensuring that all cooling tubes are uniformly cleaned. In each case by a suitable number of the rubbing bodies participating in the cleaning circulation, a cleaning of all the cooling tubes is ensured. The impurities are removed again from the cooling tubes in the shortest possible time according to the number of the rubbing bodies without any soiling of the cooling device of practical importance first taking place. By choosing a number in accordance with the cooling water qualities and the cooling surface of the condenser, and by the possibility of using at the same time rubbing bodies having different friction qualities, the maximum possible heat transmission may be maintained in the cooling tubes.

In this method of self-cleaning the cooling water capacity of the condenser is only little influenced by the rubbing bodies. The fact that a small amount of heated cooling water enters the cooling water with the returned rubbing bodies has likewise little practical effect upon the vacuum obtained in the condenser, more particularly in view of the gain

which is permanently obtained by the relatively clean condenser cooling surface.

The device 23 for cleaning the used rubbing bodies may, with advantage, be constructed as a funnel-shaped cataract, and one suitable form will now be described with reference to Figs. 4 to 8. In the cooling water outlet pipe indicated by the reference numeral 1, is mounted a funnel-shaped cataract 2 at the lowest point 3 of which the rubbing bodies are returned to the shunt or return tube 4 of the water circulation circuit. The cataract 2 is formed of individual rings 6 disposed coaxially in a step-like manner and held together by supporting bars 5. As will be seen more clearly in Figs. 6 and 7, the rings 6 are stream-lined in cross-section, that is to say, their cross-section may be drop-shaped or shaped similarly to steam-turbine blades. The spacing a of the rings 6, is subject to the general condition that it must be smaller than the diameter of the rubbing bodies 7; it is, however, advisable to reduce this distance further to a value smaller than the radius r of the bodies 7 in order to avoid the risk of any rubbing bodies becoming wedged and stuck between the rings. In this manner it is ensured that the rubbing bodies 7 will roll downwardly over the rings 6.

The rings of the cataract are preferably staggered in such a manner that the flow of cooling water can only cause the rubbing bodies to impinge upon, and thus be pressed against, the edge of one ring at a time ensuring particularly high deforming pressure on the rubbing bodies. Owing to this the rubbing bodies are relatively heavily compressed and in repeated alternation subsequently expanded which is favourable for freeing the rubbing bodies as completely as possible from any bodies carried along. The flow resistance of the cataract funnel may be reduced to a very small value by making the ring surfaces smooth, for example by enamelling them or coating them with foil. The direction of flow prescribed for the interception and conduction of the rubbing bodies is produced by the blade rings of the funnel-shaped cataract 2. The cooling water thus conducts the rubbing bodies to the middle of the funnel and into the return conduit 4 there provided. The height of the funnel-shaped cataract device is advantageously approximately equal to the radius of the cooling water conduit.

The cataract funnel 2 is adapted to be tilted, during the operation of the condenser, about two trunnions 8 or a shaft secured on a holder ring 9 (Figs. 8 and 9). In this manner impurities which have settled between the blade rings may be rinsed off.

This smoothening and making durable of the blade surface, for example the enamelling, is simpler in the case of the proposed insertible blade rings than in the case of the straight bars of a rake or grate, because the latter are in most cases rigidly connected to cross bars and are therefore liable to become warped at the high temperatures of the enamelling process resulting in unusable products.

Referring now to the modified form of the funnel cataract illustrated in Figs. 10 and 11, the funnel is divided in two halves which two halves are adapted to be tilted apart as shown in Fig. 11. In this manner then the desired cleaning result is also obtained.

In the further modified construction illustrated in Figs. 12 and 13, a rotatable scraper 10 is arranged inside the cataract funnel 2, this scraper being adapted to be put into rotation by means of a shaft 11, for example under the action of a turbine blade 12 acted upon by the flow of water, the rotation taking place continuously or at intervals as desired.

It will be appreciated that only a few of the many possibilities of the automatic cleaning of the funnel-shaped cataract, taking place from time to time or continuously, have been described herein by way of example.

For the acceleration of the water circulation through the shunt or return conduit 4 use may be made of an acceleration pump according to the invention of special construction as schematically illustrated in Fig. 14. In this figure 13 indicates a substantially cylindrical rotor the peripheral surface of which takes the water along in a spinner-like manner and by boundary layer adhesion. By means of a stationary flow lock 14, which may, for example, extend over one-sixth of the circumference, and which allow allows the rotor 13 to pass with a small distance between the lock and the peripheral surface of the rotor, a predetermined flow in the pump chamber is ensured.

It further appears advantageous, in order to ensure uniform distribution of the rubbing bodies of the tube bundles of the condenser and in order to increase the velocity and thereby the cleansing effect of the rubbing bodies in the condenser tubes, to supply the rubbing bodies from the shunt circuit to a trough which by slow rotation places itself in turn in front of all the tube ends of the condenser or the like, thus ensuring that the rubbing bodies must flow in turn through all the tubes. By the increased pressure of the rubbing bodies a flow through of the tubes is also ensured.

Cooling tubes of old condensers are in

2. A method as claimed in Claim 1, characterised in that the rubbing bodies coming out of the tubes are conducted in continual succession over a cataract which permits the spent medium to pass substantially without hindrance but which holds back the rubbing bodies in a sieve-like manner subjecting the same to repeated impacts, thereby elastically deforming the rubbing bodies, freeing them from retained impurities.

3. A method as claimed in Claim 1 or Claim 2, characterised by the use of a funnel-shaped cataract.

4. A method as claimed in any one of Claims 1 to 3, characterised in that some of the rubbing bodies separated from the spent medium are removed from the circulation, the removed rubbing bodies being either returned into circulation after thorough regeneration or being replaced by others.

5. A method as claimed in any of Claims 1 to 4, characterised in that the rubbing bodies are introduced into the tubes through a trough or like member which is arranged to move slowly in front of the entrances of the various tubes so as to introduce the rubbing bodies in turn into each tube inlet thereby ensuring that rubbing bodies are introduced in turn into all the tubes for cleaning the same.

6. A method as claimed in any of Claims 1 to 5, characterised by the use of rubbing bodies having a coating of an elastic binder containing a granular abrasive substance corresponding in hardness substantially to the metal of the tubes.

7. A method as claimed in any of Claims 1 to 6, characterised by the use of porous rubbing bodies, for example rubbing bodies made of sponge rubber.

8. A method as claimed in any of Claims 1 to 7, characterised by the use of spherically shaped rubbing bodies.

9. Apparatus for carrying out the method as claimed in Claim 1, characterised in that the rubbing bodies, in order to obtain uniform cleaning of the tubes, receive by fixed guiding means such as deflector sheets and the like, or by moving devices, in the supply flow a predetermined direction of movement.

10. Apparatus for carrying out the method according to Claim 1, characterised by a conduit for the circulation of the rubbing bodies, connecting the outlet and inlet sides of a condenser and opening into the suction connection of the cooling water jump for the condenser.

11. Apparatus according to Claim 10, characterised in that the rubbing bodies are arranged to arrive directly into the suction connection of the condenser cooling water pump.

12. Apparatus as claimed in any one of Claims 9 to 11, characterised by a funnel-shaped cataract device comprising a plurality of ring members having an approximately drop-shaped cross-section said members being arranged co-axially with each other in staggered, step-like manner being held by radially extending supporting bars.

13. Apparatus as claimed in Claim 12, in which the width of the passages between the individual ring members of the the cataract device are equal to, or smaller than, the radius of the preferably ball-shaped rubbing bodies.

14. Apparatus as claimed in Claim 12 or Claim 13, characterised in that the cataract device is rotatably mounted in a conduit for the spent medium.

15. Apparatus as claimed in Claim 12 or Claim 13, characterised in that the funnel-shaped cataract device is devided in two halves along an axially extending plane, said halves being adapted to be tilted apart.

16. Apparatus as claimed in any of Claims 12 to 15, characterised in that the supporting elements of the ring members of the cataract device are arranged at the outlet side of said members and that a rotary scraper is arranged above the ring members.

17. Apparatus as claimed in Claim 16, characterised in that the rotary scraper is adapted to be rotated continuously or at intervals by a propeller wheel arranged within, and acted upon by the flow of cooling water or the like.

18. In apparatus as claimed in any one of Claims 9 to 11, the provision of cataract devices in Claim 1, substantially as described with reference to Figs. 4 to 9, or to Figs. 10 and 11, or to Figs. 12 and 13, of the accompanying drawings.

19. Apparatus as claimed in any one of Claims 9 to 11, characterised by a circulation pump for the return of the rubbing bodies, said pump having a delivery cylinder acting by boundary-layer adhesion and in a spinner-like manner, and part of the peripheral surface of said cylinder being rendered ineffective for the water passage by a flow lock.

20. Apparatus as claimed in Claim 19, characterised in that at a small distance from the free peripheral surface of the delivery cylinder a cage is arranged which keeps the rubbing bodies away from it.

21. Apparatus as claimed in any one of Claims 9 to 11, comprising a circulation pump substantially as described with reference to Fig. 14 of the accompanying drawings.

many cases covered with a stony deposit which has formed after a number of years of operation. Such deposit cannot be removed by elastic rubbing bodies, for example rubbing bodies of sponge rubber such as are provided in the case of new condensers originally equipped for the method according to the invention. For the initial cleansing and the removal of hard fur or the like in cooling tubes rubbing bodies are more suitable which consist of elastic material but the surface of which consists of a binder with a granular abrasive substance. In order to reduce damage to the tubes it is advisable to employ for this purpose a coating of the rubbing bodies which is permeated by filings or metal dust of the same material as that constituting the cooling tubes. Since these rubbing bodies of more rigorous action would attack the cooling tubes after removing the fur, it is necessary for them to be removed again from the circulation circuit after a certain time of operation. For this purpose it is advisable to provide a lock or other suitable device in the circulation conduit 4 or 24 which enables the rubbing bodies to be led off.

In condensers which from the beginning are operated by the auto-cleaning methods hereinabove described, these devices may be utilised for removing from the circulation circuit and replacing by others rubbing bodies which have become ineffective by wear of rubbing bodies which, under certain conditions of operation, have become excessively loaded with foreign bodies.

In order to reduce wear of the walls of the acceleration pump shown in Fig. 14, cage-like structures may be arranged in the pump chamber which prevent contact of the rubbing bodies with the walls of the pump. This feature is particularly advantageous when rubbing bodies having abrasive coatings are employed.

The condenser auto-cleaning method according to the invention has various advantages as compared with the hitherto known methods of cleaning.

The heat transmission of the condenser cooling tubes, and accordingly the vacuum in the condenser, reach, due to the relatively frequent cleaning of each individual cooling tube and the gentle treatment of the material of the cooling tubes, a high value practically equal to the maximum value. The cost of installation and operation is extremely small, more particularly under normal conditions, i.e., in the case of the omission of the return pump and the connection of the return conduit for the rubbing bodies to the intake connection of the cooling water pump (Fig. 3). In the case of the elimination of the return pump, the cleaning of the condenser commences automatically when the same is taken into operation but it may, if no longer required, be stopped at any time by a simple stop member 26 in the return tube 24 of the rubbing-body circulation without appreciably affecting the operation of the condenser. This means low cost of attendance and considerable increase in the readiness for operation of the machine plant.

As a consequence, divided water chambers and twin condensers are also redundant to some extent if they are exclusively provided for condenser-cleaning purposes.

Another substantial advantage of this method is the elimination of a separate conditioning treatment of the cooling water for the removal of organic substances and hardness-forming substances.

The method of cleaning may, in addition to surface condensers, also, under suitable conditions, be applied to other tube type heat exchangers.

Apparatus has already been proposed for internally cleaning the tube coils of water-tube boilers or the like by friction bodies. This apparatus comprises a tube connecting the ends of the tube coil. Into this tube opens a separate pressure conduit. By simultaneous and alternate opening and closing of the stop members in the pressure tube and in the connecting tube the rubbing bodies are forced through the tube coil. The operation of the stop members is effected manually. The important differences, as compared with the condenser auto-cleaning method of the invention, are constituted by the presence of a connecting-tube between the tube ends of the tube to be cleaned, in the stop members which must be manually controlled, in the separate pressure means for the circulation of the rubbing bodies, and in the fact that the cleaning can only be carried out when the boiler is out of operation. Moreover, in continuous operation the rubbing bodies may be partly removed from the circuit, and re-introduced after re-generation or replacement.

What I claim is :—

1. Method of auto-cleaning the tubes of heat exchangers such as surface condensers, coolers and the like, in which rubbing bodies are arranged to be conveyed by a heat exchange medium such as cooling water along the walls of the tubes, said bodies being separated from the spent medium leaving the heat exchanger by means of an intercepting and guiding device, such as a screen, a cataract or the like, and being returned to the inlet of the heat-exchanger and introduced into the fresh medium entering the heat exchanger.

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SHEET 1

Fig. 1.

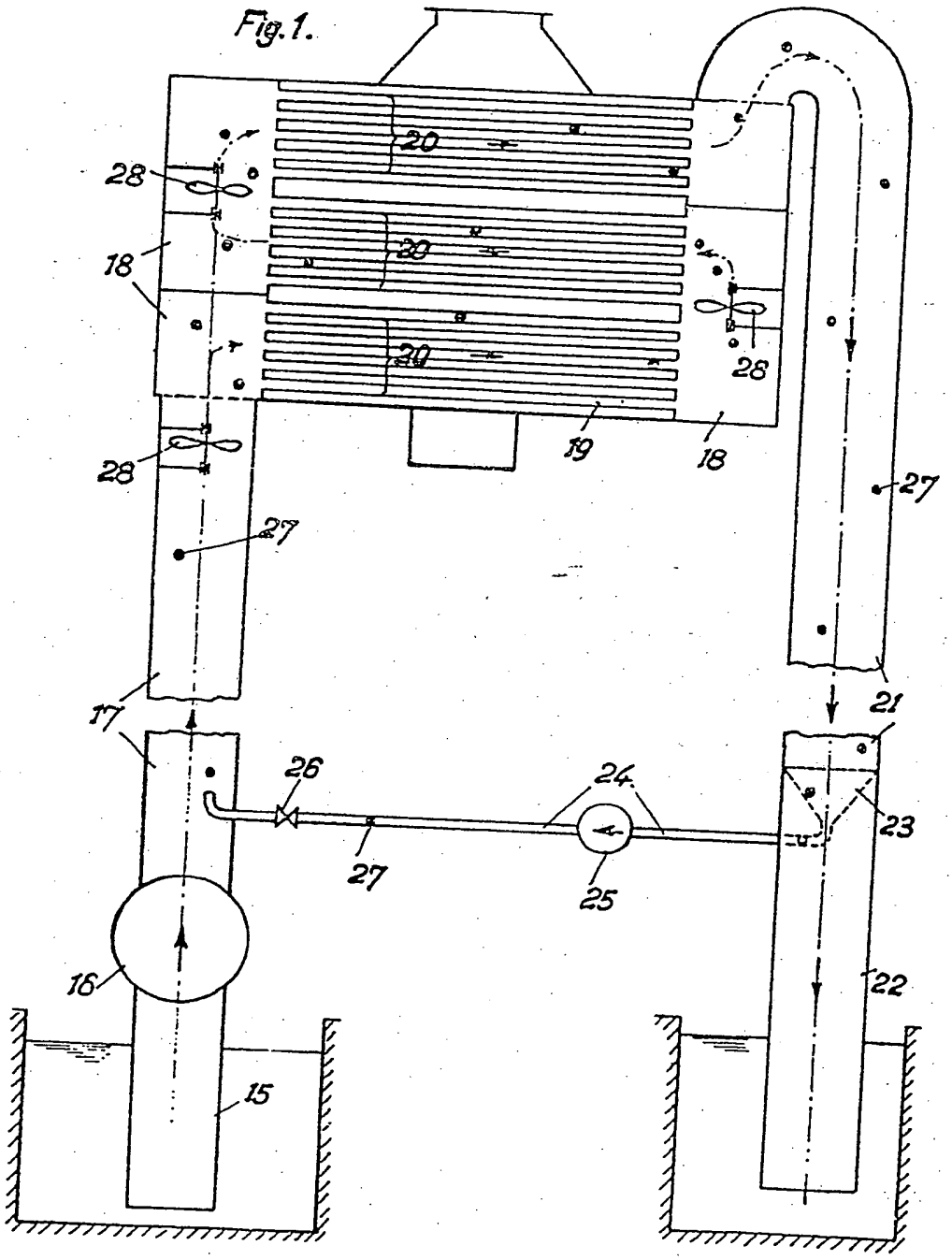

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Fig.2.

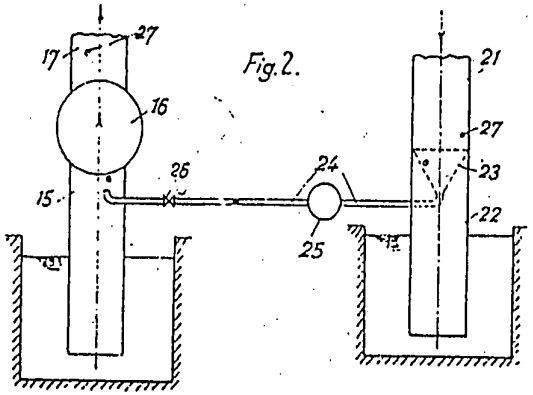


Fig.3.

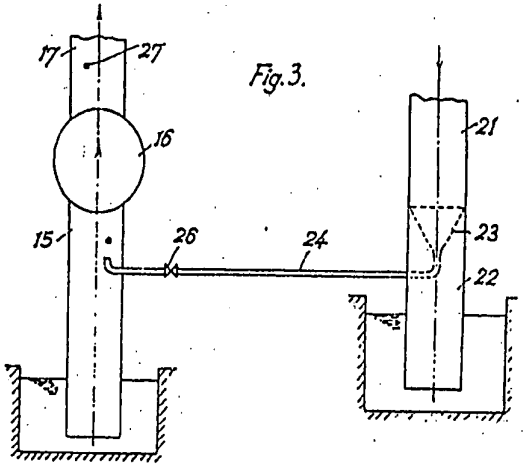


Fig.4.

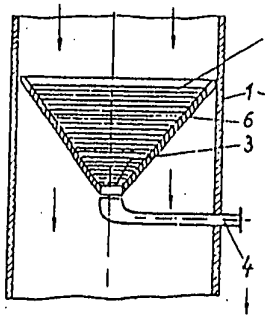
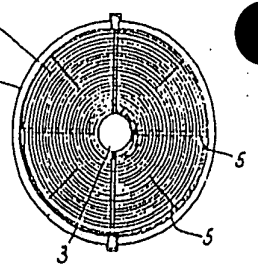


Fig.5.



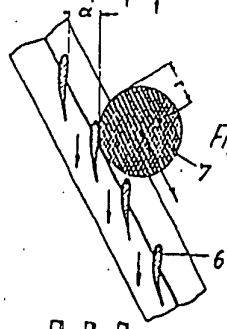


Fig.6.

Fig.7.

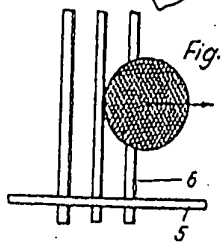


Fig. 8.

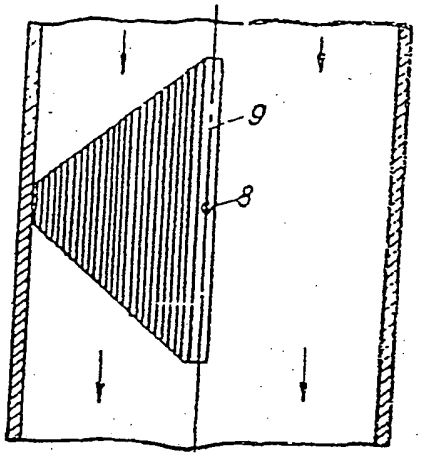


Fig. 9.

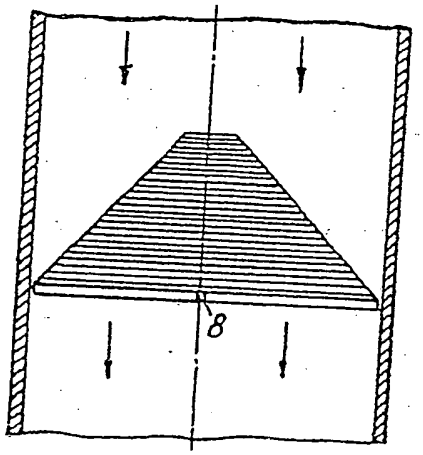


Fig. 10.

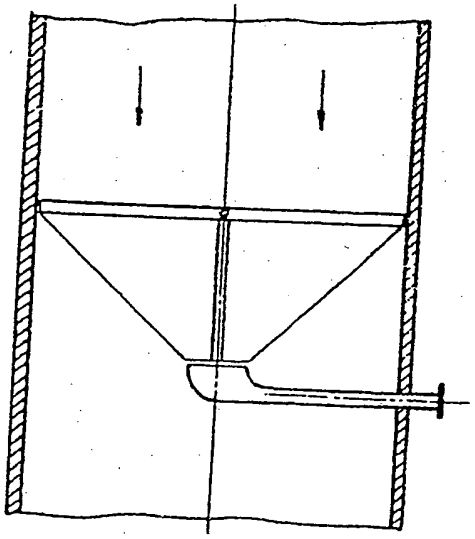


Fig. 11.

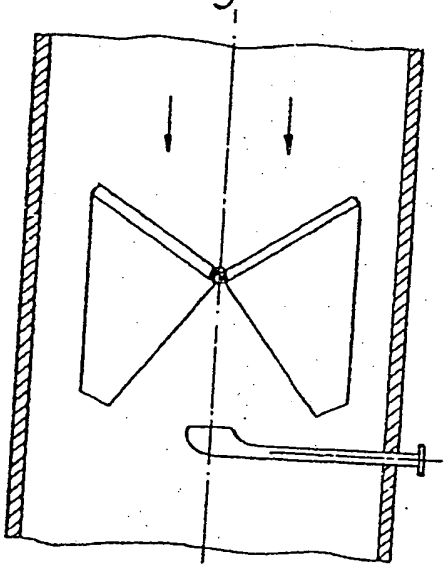


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Fig. 8.

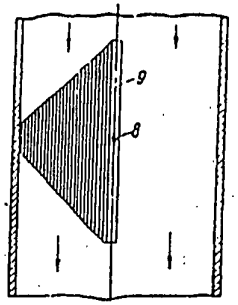


Fig. 9.

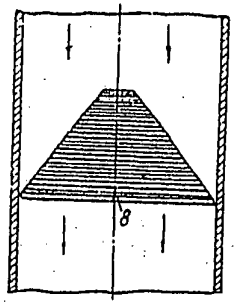


Fig. 10.

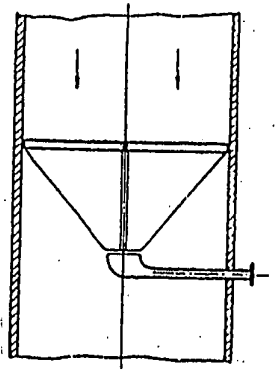


Fig. 11.

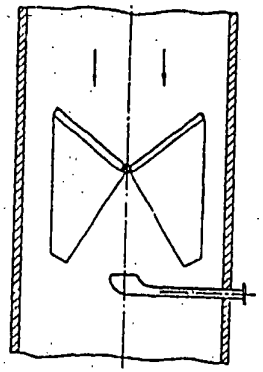


Fig. 12.

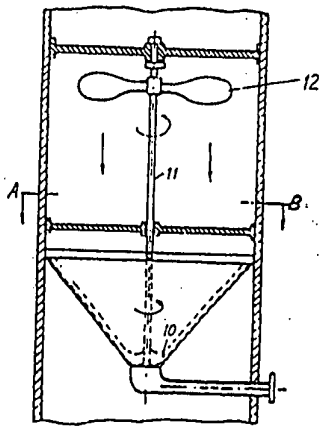


Fig. 13.
Section A-B

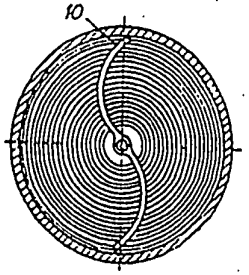
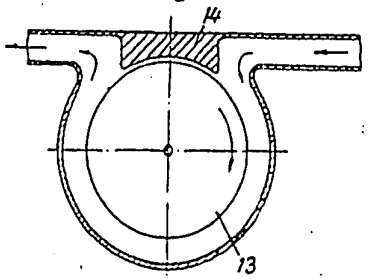


Fig. 14.



700.833
5 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 4 & 5

Fig. 12.

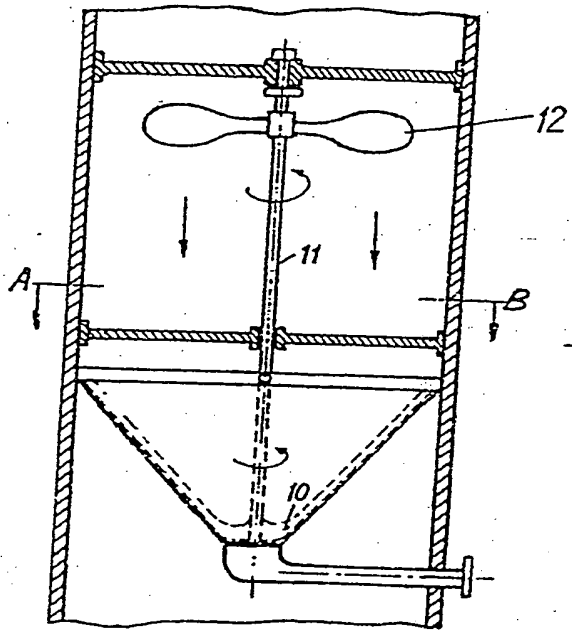


Fig. 13.
Section A-B

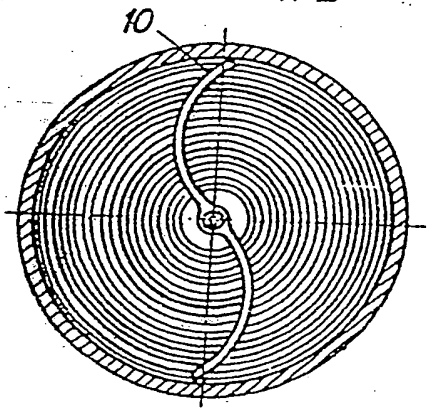
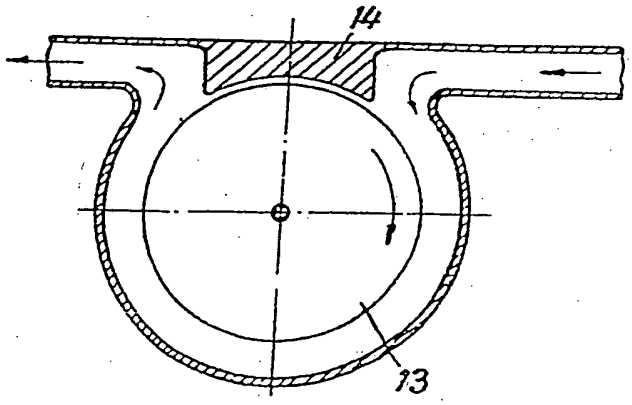


Fig. 14.



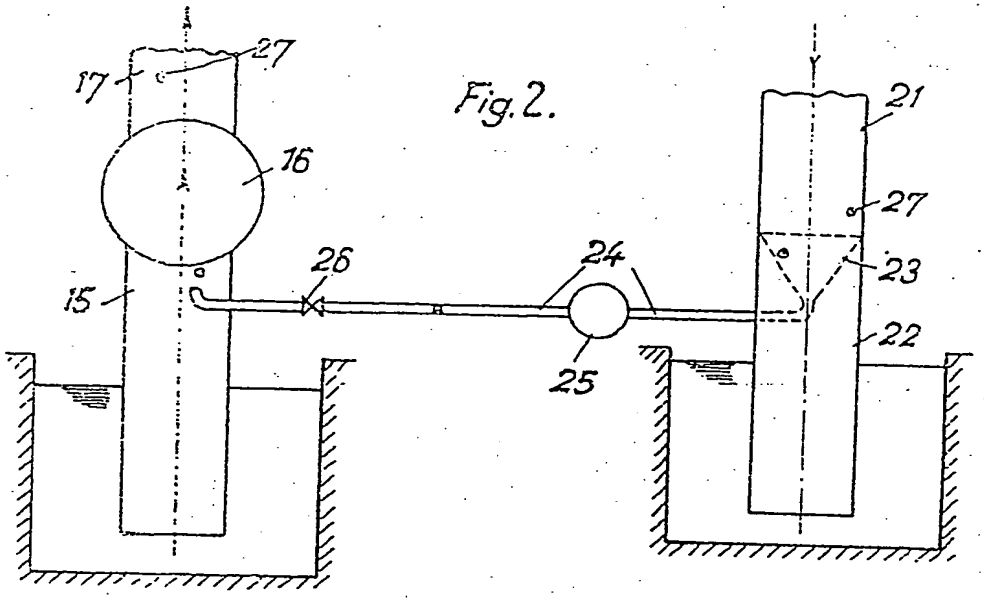


Fig. 2.

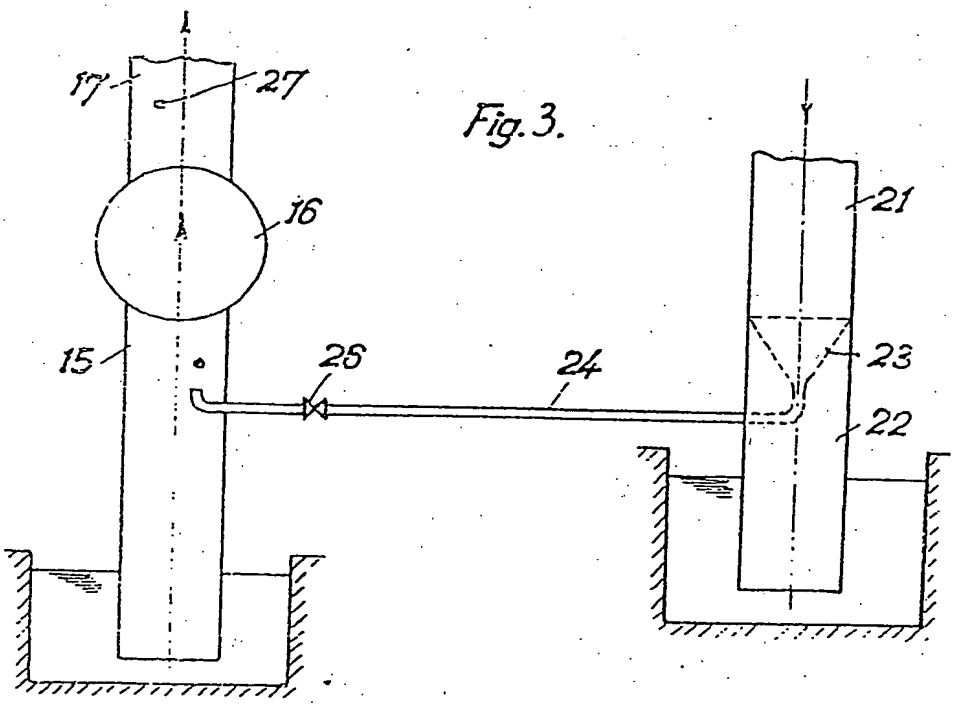


Fig. 3.

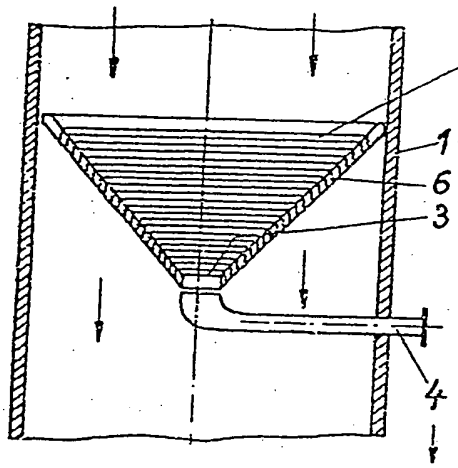
700,833 COMPLETE SPECIFICATION

5 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 2 & 3

Fig.4.



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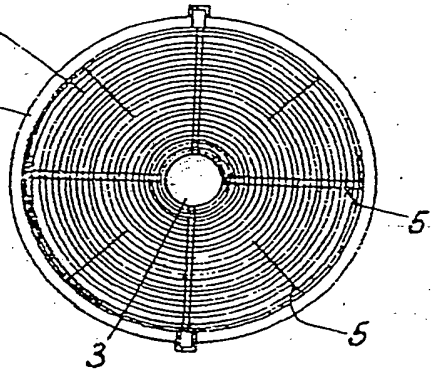

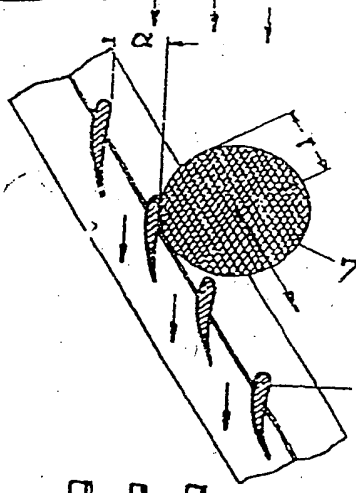

Fig.6.

Fig. 7.